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Morphology Analysis, Production, and Quality of Gayo Shallot (*Allium cepa* L.)

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Abstract Gayo shallot (*Allium cepa* L.) is a local shallot cultivar from Central Aceh province that has just received a national superior shallot variety certificate. The objective of this study was to scientifically determine the superiority of Gayo shallots compared to other national superior varieties based on morphological characters, production, and quality of tubers. The study was conducted from July to December 2020. The field study was carried out in Lut Tawar Sub-district, Central Aceh Regency, while laboratory analysis was conducted at the Agroecotechnology Laboratory of the Faculty of Agriculture, Universitas Malikussaleh. This research used a single-factor randomized block design (RBD) with three replications. The treatments consisted of three varieties: local shallots Gayo, Batu Ijo, and Tajuk. Each unit treatment consisted of 5 plants, resulting in a total of 165 plants. The results showed that Gayo shallots' growth and performance differed from Batu Ijo and Tajuk. The height and number of leaves per clump of Gayo and Tajuk shallot plants were not significantly different. Gayo shallot plant height was 28.50 cm and Tajuk was 28.30 cm, and the number of leaves per Gayo shallot's clump reached 17.80 and Tajuk 15.50, while Batu Ijo's height was 36.05 cm and the number of leaves per clump was 28.10 at 8 weeks after planting (WAP). Batu Ijo had better growth and yield of tubers than Gayo and Tajuk shallots. Regarding similarity, the physical appearance of plants and tuber yields from Gayo was more similar to Tajuk (67%) compared to Batu Ijo (57%).

Keywords Growth, Yield, Varieties, Tuber Weight

1. Introduction

Indonesia is an agricultural country well known as a center of origin of horticultural plant resources [1], [2]. Shallots (*Allium cepa* L.) are among Indonesia's leading horticultural crops intensively planted and cultivated by farmers [1], [3]. Shallots are included in essential spices [4], [5], and medicinal plants because shallots cannot be substituted [6]–[8]. Shallots can function as food flavoring and coloring, condiments in pickles and salads, and processed products (fried shallots) [9], [10]. Shallot bulbs are also used for traditional medicines as antimicrobial, anticancer, and anti-inflammatory [11]–[14].

Essential oil is an important chemical component in shallot bulbs [15], [16]. The content of essential shallot oil dramatically affects the quality and consumer preference for shallots. This is because the essential oil content of shallots will affect the strength of the aroma of the shallots. The more pungent the smell of the shallot, the higher the essential oil content. The essential oil content in shallot bulbs ranges from 0.11-0.45%.

Gayo shallot is a local variety from Central Aceh that has just received a national superior shallot variety certificate. Gayo shallot production in Central Aceh reaches 13 tonnes/ha with a potential yield of 16.83

tonnes/ha, tubers per clump of up to 10 bulbs, an average weight of 15.25 grams, and a harvest age of 72 days.

Gayo shallot cultivation is still limited to Takengon and its surrounding areas in Central Aceh. The popularity of the Gayo shallot in Indonesia and even Aceh Province is still shallow compared to other superior national varieties such as Batu ijo and Tajuk. This is due to the lack of information available about the superiority of Gayo red shallots.

Gayo shallots have a more pungent aroma than other types of shallot, and they have attractive shiny red bulb colors. Furthermore, they also have good productivity that is not inferior to other national superior shallots. Limited information about the superiority of Gayo shallots and the lack of government and community attention to local plant species have caused the price of Gayo shallots to decline. This situation might lead to the extinction of Gayo shallots since people are not interested in cultivating them. This often occurs in other superior local plants, for example, the national superior red shallot Samosir from North Sumatra. Today, Samosir red shallots are very difficult to find, and their existence is being replaced by much lower-quality varieties [17]. Therefore, it is necessary to immediately carry out various studies that reveal the multiple advantages of the Gayo national superior shallot from Central Aceh.

This study aimed to determine Gayo shallots' differences in growth, yield, and quality with the superior national varieties of Batu Ijo and Tajuk. The superiority of the Gayo shallot over the superior national varieties of Batu Ijo and Tajuk was analyzed based on the plants' morphological markers, growth, and yield.

2. Methodology

The field study was conducted in Lut Tawar Sub-district, Central Aceh Regency while laboratory analysis took place at the Agroecotechnology Laboratory, Faculty of Agriculture, Universitas Malikussaleh. The research was conducted from July to December 2020.

The materials used in this research were Gayo national superior shallot, Tajuk, and Batu Ijo, NPK, SP-36, urea, and KCl fertilizers were also used. The shallot bulbs were obtained from the Agricultural Extension Center, Bintang Sub-district, Central Aceh Regency. The tools used were hoes, rakes, shovels, machetes, and hand tractors.

This research used a single-factor randomized block design (RBD) with three replications. The treatments consisted of three varieties: local shallots Gayo, Batu Ijo, and Tajuk. Therefore, nine experimental units were obtained. Each experimental unit was a bed measuring 1.5 x 1.20 m. Shallots were planted at a distance of 20 x 15 cm so that a bed could accommodate 60 plants were obtained per bed.

Shallot propagation was done using tubers as shallot seeds. The quality of shallot seeds greatly determines the yield of shallots. Good tubers for shallot seeds must come from quite old plants 70-80 days after planting, weighing 5-10 grams, and having a diameter of 1.5-1.8 cm. The seed tubers must be healthy and should not contain germs and pests. At the end of the shallot seed tubers, about 1/5 of the tuber length was cut to accelerate shoot growth.

The land was cleared of weeds, rocks, and plant debris; then, the soil was tilled. The soil was formed with beds measuring 1.5 x 1.2 m, with a height of 20-25 cm. The distance between the beds was 40 cm, made into a trench as deep as 50 cm.

Fertilization was given in a basic fertilizer by applying it all at once. Basic fertilization was carried out in all treatments with the same dose using NPK Mutiara (16:16:16) 500 kg/ha, 50-100 kg/ha of SP-36, and 30-60 kg/ha of KCL. This fertilizer was used because the P and K elements are difficult to dissolve, so it takes time (at least 14 days) for these elements to be absorbed by plants. At the age of seven days, the roots of the shallot plant begin to grow and require these elements for their development. P and K elements from NPK, SP-36, and KCl will be available to plants along with the growth of the shallot.

The first follow-up fertilization was given when the plants were 10-15 days old using urea in 180 kg/ha and 400 kg/ha of ZA. Fertilizer was applied by sowing it on the beds. This fertilization aims to provide food reserves for the tubers as at 15-30 days, the tuber food reserves run out quickly, so N and S elements are needed to form leaves, stems, and roots.

The second supplementary fertilizer was applied when the plants were 30-35 days old with 180 kg/ha of urea. In this stage, the plant enters the tuber formation phase, requiring photosynthetic carbohydrates as a material for tuber formation. Elemental N from urea is used in the photosynthesis process to form carbohydrates.

The beds were watered the day before planting to moisten the topsoil. After it was a bit dry, strokes parallel to the width of the bed and 2-3 cm deep were made. The spacing used was 20 x 15 cm. Then, the seedlings were immersed in an upright position and covered with soil. Planting shallow shallots cause the plants to collapse easily; on the other hand, planting too deep might inhibit shoot growth because they are covered by soil.

Harvesting was done 85 days after planting (DAP), marked by yellowing, dry and fallen leaves. The shallot bulbs were bigger, and some appeared on the soil's surface, the tuber joints appeared solid, and the skin color was shiny. Harvesting was done by pulling out the plants and then cleaning the plants from all dirt.

Observations were conducted on the number of leaves per clump (strands), plant height (cm), plant weight (g), tuber volume (ml), wet tuber weight (g), dry tuber weight (g), and salable tuber weight (g). The data obtained from the observations were analyzed using the F test at a 5% level. If a difference in treatment is found, Duncan’s Multiple Range Test (DMRT) level of 5% was conducted. The data obtained were also analyzed descriptively by

recording things related to the morphological characters of the vegetative and generative parts of the plant, which were displayed in the form of standard blanks.

Morphological analysis was conducted through an index study by matching the sample with the description list from IPGRI [18]. The morphological characters observed were then recorded in the morphological characteristics and quality of the tubers. Data were analyzed using the NTSYS-pc program (Numerical Taxonomy and Multivariate Analysis System, Version 2.10). This analysis used the SAHN method (sequential, agglomerative, hierarchical, and nested clustering). Genotype similarity and inequality matrices were calculated based on the Jaccard coefficient with the UPGMA (Unweighted Pair Group Method Arithmetic) of the Similarity (SIMQUAL) function. The analysis result data was displayed in the form of a dendrogram.

3. Results and Discussion

Results

Analysis of plant growth and yield

Analysis of variance showed that plant varieties significantly affected plant height. The results of the statistical tests are presented in Table 1.

Table 1. Plant heights of various shallot varieties

Varieties	Plant heights (cm)			
	2 WAP	4 WAP	6 WAP	8 WAP
Gayo	12.50 ab	18.95 b	25.50 b	28.50 b
Tajuk	11.45 b	16.80 b	23.40 b	28.30 b
Batu Ijo	14.50 a	24.75 a	33.10 a	36.05 a

Note: The numbers followed by the same letter in the same column show no significant difference based on the 5% level of the DMRT test. WAP= week after planting.

Table 1 shows that the Batu Ijo variety was the highest plant, significantly different from the other two tested varieties. In contrast, the plant height of the Gayo and Tajuk was not significantly different. Analysis of variance showed that plant varieties significantly affected the number of leaves. The results of the statistical tests are shown in Table 2.

Table 2 shows that the Batu Ijo variety had a high number of leaves per clump, significantly different from the other two varieties. The number of leaves per clump of the Gayo and Tajuk varieties was not significantly different. The number of leaves per clump of the Batu Ijo variety was more than the others found at two WAP until the last observation at eight WAP. The number of chives in the Batu Ijo variety was 10.3 strands compared to the Gayo variety and 12.6 larger than the Tajuk variety.

Table 2. Number of leaves per clump of various shallot varieties

Varietas	Number of leaves			
	2 WAP	4 WAP	6 WAP	8 WAP
Gayo	8.90 b	15.20 a	17.80 ab	17.80 b
Tajuk	6.80 b	9.50 b	12.80 b	15.50 b
Batu Ijo	13.10 a	18.60 a	26.60 a	28.10 a

Note: The numbers followed by the same letter in the same column show no significant difference based on the 5% level of the DMRT test. WAP= week after planting.

Analysis of variance showed that plant varieties significantly affected plant weight, dry tuber weight per clump, and salable tuber weight per clump. The results of the statistical tests are shown in Table 3.

Table 3 shows that the highest plant weight of shallots and dry tuber weight per clump was found in the Batu Ijo variety, significantly different from the Gayo and Tajuk varieties. Fresh tuber weight per clump showed no difference in all varieties.

Table 3. Plant weight, fresh tuber weight, dry tuber weight, and tuber weight loss of various shallot varieties per clump

Varieties	Plant Weight	Fresh Tuber Weight	Dry Tuber Weight	Tuber Weight Loss
	---------- g ----------			----------%--------
Gayo	69.70 b	44.43 a	34.97 b	24.88 a
Tajuk	76.20 b	37.90 a	26.37 b	21.40 ab
Batu Ijo	95.00 a	54.58 a	44.27 a	19.65 b

Note: The numbers followed by the same letter in the same column show no significant difference based on the 5% level of the DMRT test. WAP= week after planting.

The highest tuber weight loss was found in the Gayo variety, significantly different from the Batu Ijo variety. This is related to a larger number of leaves, affecting the photosynthate in shallot bulbs. The Batu ijo variety had more leaves than the other two varieties (Table 2).

The appearance of the leaves and bulbs of the three types of shallots was different. This could be seen from the appearance of the leaves and the quality of tubers produced by each variety. The appearance of leaf morphology and tuber properties of three shallot varieties is presented in Table 4.

Analysis of Shallots Based on Morphological Markers and Tuber Quality

Based on Table 4, it is known that the Gayo varieties differed from the Tajuk and Batu Ijo. Gayo shallots had more in common with Tajuk than with Batu Ijo. The appearance of the bulbs of the three types of shallots is shown in Figure 1. Figure 1 shows differences in the appearance of the three types of shallots. Batu Ijo had larger and more uniform onion units. Gayo has a darker flesh color (beige) than the other two types of shallots (white). A similarity coefficient analysis was done to see the level of similarity between the three types of shallots, as seen in Figure 2.

Table 4. The Characteristics of Shallots Based on Morphological Markers and Tuber Quality

Characteristics	Gayo	Tajuk	Batu Ijo
Leaf color	Green	Light green	Dark green
Leaf length (cm)	27.37	28.25	28.22
Leaf width (cm)	1.00	0.75	1.01
Leaf growth	Erect	Teak	Medium
Leaf fragility	medium	fragile	strong
Dried tuber shape	broad oval	Spindle	broad oval
Tuber uniformity	uniform	uniform	uniform
Bulbs skin color	light purple	light purple	light purple
The color of the tuber flesh	cream	white	white
Number of layers of skin	5-10	5-10	5-10
Number of tubers	(<30)	(<30)	(<30)
Number of broken tubers	2-3	2-3	2-3
Flowering ability	No flowers appeared	Flowering	Flowering

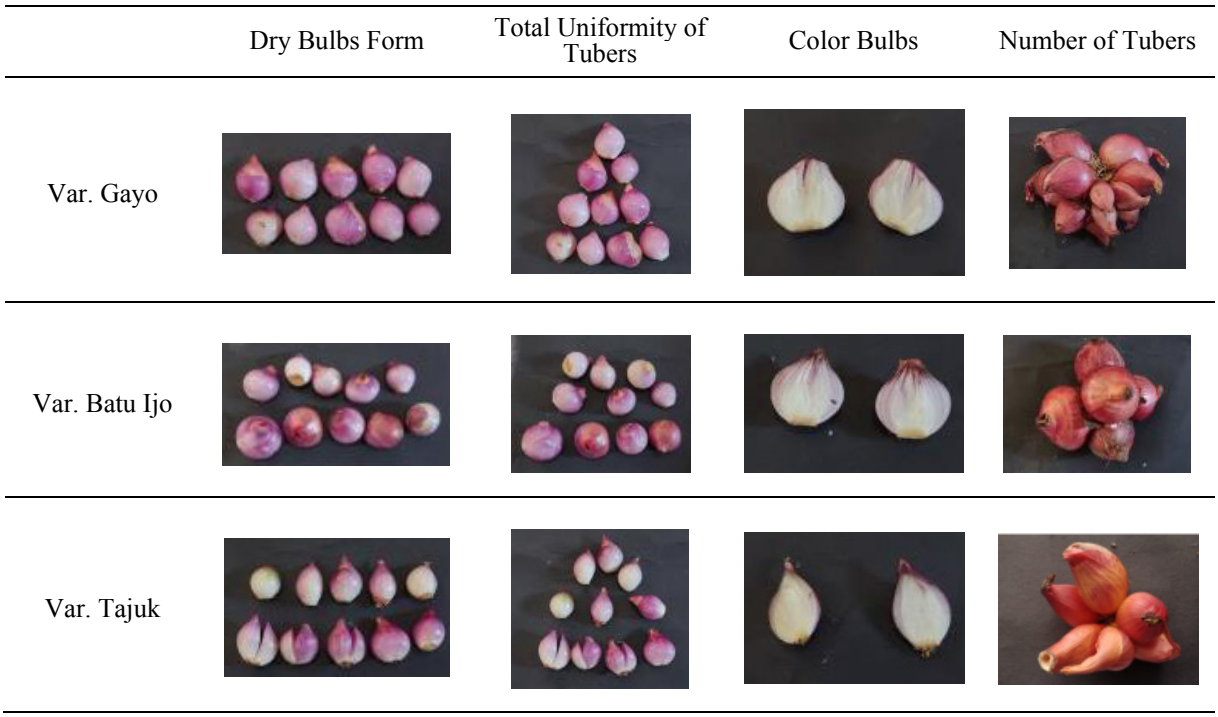

Figure 1. Form of dry tubers, tuber uniformity, the color of tuber flesh, and the number of tubers of several varieties of shallots

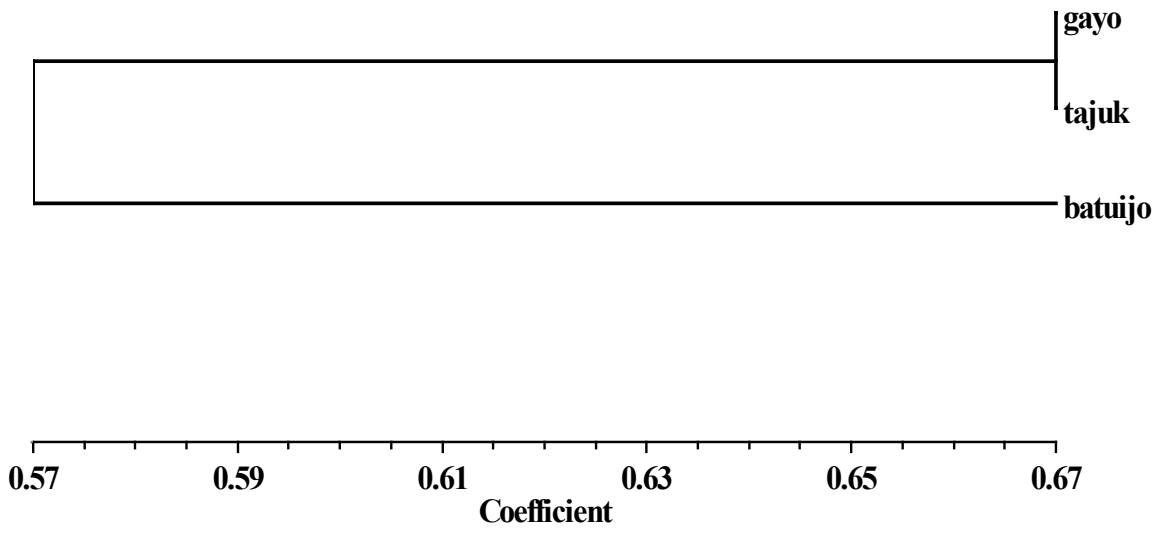

Figure 2. The similarity dendrogram of three shallot varieties

Figure 2 shows a similarity coefficient range of the three types of shallots between 0.57– 0.67 (57% – 67%). Gayo shallot had a 67% similarity with Tajuk, while Batu ijo was only 57%. This can be seen based on the morphological characteristics and bulbs of shallots.

Discussion

Gayo shallot has several differences from Tajuk and Batu Ijo shallots. This can be seen in almost all of the observed variables. Gayo shallots were more similar to Tajuk than Batu ijo. The Batu plant was taller and had more leaves than Gayo and Tajuk shallots. References [19], [20] show that the Batu Ijo variety was taller than the Gayo shallot. The number of leaves and plant height greatly affect plant growth. The number of leaves of the Batu ijo variety was larger than the other two varieties (Table 2), so the bulb of the Batu Ijo variety was heavier than the Tajuk and Gayo varieties (Table 3). The vegetative growth of plants will ultimately determine the generative phase and yield of the plant [21]. This is because good vegetative growth will cause the photosynthesis process to run well. Photosynthesis results can stimulate the formation of larger tubers; therefore, the tuber weight increases [22].

Gayo shallot yields did not differ from the Tajuk variety in all observed variables except for the tuber weight loss. Gayo shallots even had a better mean value, although statistically, there was no difference (Tables 1, 2, and 3). Gayo and Tajuk shallots are grown in the highlands. Both showed good yields because they were planted in the highlands; however, when grown in the lowlands, Tajuk shallots grow better than Gayo [20].

Genetic and environmental factors largely determine plant productivity. The variety's adaptability to the environment is strongly influenced by the environment in which they grow. The use of various varieties in the same growing environment will provide an overview of the adaptability of varieties [23]. A cultivar originating from the same area but in a different growing environment will affect genetic diversity. Also, genotypes originating from the same area are not always in the same group [24].

Gayo yields were still lower than Batu ijo. This can be seen from the plant weight, dry tuber weight per clump, and tuber weight loss (Table 3). Batu Ijo variety had large tubers, a sturdy appearance, and tall and broad leaves resembling Bombay onions [20], [25]. Batu ijo is currently one of the leading varieties of shallot that has grown for decades in Batu, East Java. It is a high-yielding variety specific to the highlands and lowlands [25] and is a specific superior variety in highland and lowland areas [26]–[29].

The physical appearance and bulbs of the Gayo variety were more similar to Tajuk than Batu Ijo. This can be seen from the morphology and dendrogram of the similarity coefficient (Table 4, Figures 1 and 2). The tubers were generally uniform with light purple skin and cream and white flesh colors. Shallot bulbs were usually uniform; delicate purple skin and cream and white flesh colors. The third layer of tuber skin varieties was 5-10 layers and 2-3 tuber fragments. The obvious difference was that Gayo shallots could not flower, while the other two varieties could. The tuber skin layer of the three varieties was 5-10, and the tuber fraction was 2-3.

The obvious difference that can be seen is that no flowers appeared in gayo shallots, while the other two varieties grew flowers. The results of the similarity analysis based on vegetative and tuber morphology showed that there were groupings of plant similarities. The dendrogram of the similarity coefficient of the three varieties of onion based on vegetative and tuber morphology had a range of 0.5 – 0.67 (Figure 2).

The dendrogram showed that the Gayo shallot had a high similarity with Tajuk (67%) rather than with Batu Ijo

(57%). Analysis of kinship based on morphological characters is relatively easier and more efficient. This analytical method is sufficient to see the level of the kinship of plants based on their morphological characteristics, which is a manifestation of their genetic appearance. However, the results are not as accurate as the analysis using molecular markers [24], [30].

Gayo shallot is a leading commodity in Gayo Lues, Aceh, which enriches Indonesia's genetic resources. The superiority of the Gayo shallot is that it has a relatively more resistant shelf life and can be grown at an altitude of 1500 meters above sea level [20]. However, the productivity of the Gayo variety will decrease if it is planted in the lowlands. The productivity of the Gayo variety is still lower than Batu Ijo, but Gayo has a more pungent aroma than Batu ijo or Tajuk.

4. Conclusion

Based on the results of the study, it can be concluded that 1) The growth and performance of Gayo shallots were different from Batu Ijo and Tajuk. Batu Ijo had better growth and yield of tubers than Gayo and Tajuk shallots. 2) The physical appearance of plants and tuber yields from Gayo was more similar to Tajuk than Batu Ijo. 3) Gayo shallot had higher percentage of similarity level with Tajuk compared to Batu Ijo.

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